BRINE EVAPORATION: AN ALTERNATIVE MODEL FOR THE FORMATION OF CARBONATES IN ALH84001.

H. Y. McSween Jr.[1] and R. P. Harvey[2], [1]Department of Geological Sciences, University of Tennessee, Knoxville TN 37996, USA (mcsween@utk.edu), [2]Department of Geological Sciences, Case Western Reserve University, Cleveland OH 44106, USA (rph@po.cwru.edu).

Globules and lacy networks of Mg-Fe-Ca carbonates occur within impact-produced fracture zones in the ALH84001 martian meteorite. Because these carbonates are associated with the hydrocarbons, putative biogenic minerals, and microfossils that collectively have been cited as evidence for ancient martian life [1], it is critically important to understand their formation. Previous hypotheses invoke either alteration of the rock by hydrothermal fluids at relatively low temperatures [2] or formation from a CO_2-rich vapor at high temperatures [3].

In the spirit of multiple working hypotheses, we explore an alternative mechanism, that of direct precipitation from an evaporating brine. The evaporative saline waters may have ponded in a restricted drainage basin, such as an impact crater, and infiltrated fractures in the crater floor. High-albedo features in some martian craters have been interpreted as playas formed by evaporation [4], martian soil analyses indicate high salt concentrations [5], and brines have been implicated in the alteration of martian meteorites [6]. Evidence for evaporation on Mars must be balanced against the likelihood that surface water might freeze rapidly, but high solute concentrations would depress the freezing point of brines.

The compositions and zoning trends of the carbonates in ALH84001 [3] appear to be broadly consistent with this model, and associated sulfides and silica and lack of phyllosilicates are characteristic of some terrestrial evaporites. The isotopically heavy C of the carbonates [6] is easily reconciled with a requirement for previous cycling of C through the martian atmosphere, and evaporation provides an alternative explanation for the observed O isotopic fractionations [7]. Although minor Fe-sulfate was tentatively identified in ALH84001 [8], the lack of abundant sulfate and other salts seems inconsistent with an evaporite deposit. However, terrestrial alkaline lakes are commonly stratified so that the precipitation sequence is developed as geographically concentric zones. Near the edges of evaporating lakes, carbonate zones showing progressive Mg enrichment can form, without associated sulfates and other salts. Occlusion of pore spaces in the underlying rocks with carbonate before the onset of sulfate precipitation may also explain explain the absence or salts.

The formation of carbonates by this mechanism implies that they are relatively old, and that their radiometric ages may be indeterminate unless an isochron involving evaporites alone can be measured. A role for microbial organisms in the precipitation of the carbonates [1] seems possible in this environment but unnecessary, as the evidence for life can better be explained by abiotic processes. Evaporites may provide unambiguous evidence for water persisting at one location on Mars for a significant time. Consequently, formerly flooded craters in the ancient highlands may become sites of choice for exploration by future Mars landers.

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